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A comparison of the caries risk between patients who use vapes or e-cigarettes and those who use conventional cigarettes: a cross-sectional study

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ABSTRACT

Aims: Both conventional cigarette use and e-cigarette/vape use appear to have detrimental effects on oral health by promoting the development of both dental caries and periodontal disease. This study aims to compare the effects of the two with regards to dental caries risk level.

Methods: A cross-sectional study on patient records was conducted. 1251 patients who attended the dental school clinics and met the inclusion criteria were included. The Kruskal-Wallis test and multivariable ordinal logistic regression were used to compare the e-cigarette/vaping only, conventional cigarette use only, and dual e-cigarette/vaping and conventional cigarette use groups in terms of caries risk.

Results: A total of 1251 patient records met the inclusion criteria. There were 130 reported active users of e-cigarettes/vapes, 1094 active users of conventional cigarettes and 27 active users of both e-cigarettes/vapes and conventional cigarettes. The Kruskal-Wallis test showed no statistically significant difference between caries risk level among the 3 groups with 88.9% of the dual smokers (both conventional and e-cigarettes/vapes), 83.1% of the e-cigarette/vape only users, and 82.5% of the conventional cigarette only smokers being placed in the high/extreme caries risk category (P=.693). The comparison was also not significant (P=.719) when adjusting for age and gender.

Conclusion: Though the percentage of patients in the high/extreme caries risk category was highest in the dual smokers group, followed by the vaping/e-cigarette use group and lastly the conventional cigarette group, there was no statistically significant evidence of a difference between these groups.

Keywords: Vaping, smoking, dental caries, caries risk

INTRODUCTION

The popularity of e-cigarette/vape use has progressively increased over time. E-cigarettes were initially recommended as an effective aid to smoking cessation. In fact they were marketed as a safer alternative to conventional cigarettes. The detrimental systemic effects of e-cigarette/vape use have been well documented, with the outbreak of deaths due to E-cigarette or Vaping use-associated lung injury (EVALI) in 2019 resulting in a total of 68 deaths and 2,807 hospitalizations in the United States as of February 18th 2020.[2]

Vaping/e-cigarette use has been shown to significantly increases gingival inflammation.[3-8] Peri-implant parameters have been shown to be compromised in vaping patients as a result of an increased inflammatory response, indicated by an increase in the following inflammatory mediators: Tumor Necrosis Factor-alpha (TNF-a) and Interleukin-1 beta (IL-1).[9,10] In addition to elevated TNF-a and Interferon-gamma (IFN-y) levels use of both e-cigarettes and conventional cigarettes has been shown to increase the red and orange complex periodontal bacteria.[11]

Research on the effects of vaping and e-cigarette use on dental caries prevalence is limited. A case series highlighted 3 patients who presented to a private practice with atypical patterns of dental caries. All 3 patients admitted to being avid vapers using THC containing e-liquids.[12] A cross-sectional study assessed 4,618 records from the 2017-2018 National Health and Nutrition Examination Survey. This study concluded that both participants who smoked e-cigarettes as well as dual smokers were more likely to have untreated caries compared to non-smokers and non-dual smokers respectively. Dual smokers were those who used both vapes/e-cigarettes as well as conventional cigarettes.[13] A more recent cross-sectional study on patient records assessed a total of 13,098 patients. This study found that there was a

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significantly lower caries risk level for the non-e-cigarette using/non-vaping control group compared to the e-cigarette/vaping group (P<.001), with 14.5%, 25.9% and 59.6% of the control group being in the low, moderate, and high caries risk categories respectively and 6.6%, 14.3% and 79.1% of the e-cigarette/vaping group being in the low, moderate, and high caries risk categories respectively.[14]

The mechanism by which e-cigarettes may propagate dental caries has been hypothesized based on in vitro studies as follows: Some of the components of e-cigarette aerosols are sweet tasting and may act as a substrate for cariogenic bacteria. The by-products of propylene glycol, a component of e-liquids, are hygroscopic and can bind water in saliva resulting in hyposalivation, predisposing individuals to dental caries.[15] Lastly, the growth pattern and biofilm formation is thought to be influenced by vape/e-cigarette aerosols. A study found that e-cigarette aerosols significantly increased biofilm formation by *Streptococcus Mutans* (*S. mutans*) but did not affect biofilm formation of the 2 commensals. They also found that *S. mutans* exhibited higher hydrophobicity and coaggregation abilities as well as higher attachment to epithelial cells. They concluded that e-cigarettes may have the ability to dysregulate the homeostasis of oral bacteria.[16]

The effects of tobacco use on oral health have been well investigated with evidence suggesting that it leads to the progression of both periodontal disease and dental caries.[17] Tobacco smoking affects the ecology of the oral microbiome by deprivation of oxygen, antibiotic effects and other mechanisms which lead to microbiome dysbiosis.[18] Long term smoking has been linked with xerostomia. A recent systematic review reported that the overall prevalence of xerostomia in the general population was 26%, with 24% of combustible tobacco smokers and 33% of e-cigarette users having a diagnosis of xerostomia, that had been determined by measured low salivary flow rates or the patients' subjective sensation of dry mouth.[19]

Both conventional cigarette use and e-cigarette/vape use appear to have detrimental effects on oral health by promoting the development of both dental caries and periodontal disease. The effects of the two have not yet been compared with regards to dental caries risk level. The rationale of this study was to compare the caries risk of vaping/e-cigarette using patients and patients who smoke conventional cigarettes at a University dental school. This study is a follow-up to a previous study, conducted at the same institution, that established a significantly higher caries risk level in vape/e-cigarette-using patients when compared to a non-vaping/e-cigarette-using control. The null hypothesis was that there is no difference in caries risk between vaping/e-cigarette-using patients and patients who smoke conventional cigarettes.

METHODS

This was a cross- sectional patient record based study. Ethical approval was obtained from the Tufts University Health Sciences Institutional Ethics Review Board (Date: 03.03.2023, Decision No: (HS-IRB STUDY00003596). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. An electronic search was performed on axiUm electronic records.

The inclusion criteria were: Patients of the University dental school clinics from 01.01.2019 to 02.01.2023, above the age of 16, with a diagnosis of dental caries and a Caries Risk Assessment on record. These patients also answered 'yes' to current use of e-cigarettes and vaping and/or conventional cigarettes in the Health History questionnaire.

The exclusion criteria were: Patients without a diagnosis of dental caries and a Caries Risk Assessment on record as well as patients who answered 'no' to current use of e-cigarettes and vaping and no to conventional cigarette use in the Health History questionnaire.

The university's Caries Management By Risk Assessment (CAMBRA) form included the following 7 questions:

- Are there new or active or progressing visible cavitated carious lesions, radiographic radiolucencies in dentin?
- Are there restorations or extractions due to caries within the past 3 years or since the previous caries risk assessment?
- Is there visible heavy biofilm?
- Are there new or active or progressing initial occlusal, smooth surface, or radiographic proximal lesions not in dentin?
- Is there inadequate saliva flow per observation or measurement?
- Does the patient have a diet high in carbohydrates, sugar, acids, or frequent snacking?
- Is the patient at risk of erosion?

The CAMBRA tool has been validated in both pediatric and adult populations with numerous assessments showing a clear relationship between CAMBRA and different levels of caries; low, moderate,high and extreme risk levels.[20-25]

The patient records software, based on a pre-determined algorithm, assigned each patient to a caries risk level: low, moderate, high or extreme.

A query was made in axiUm (dental records software) by IT using Current Dental Terminology[26] codes D0120 (periodic oral evaluation-established patient) and D0150 (comprehensive oral evaluation, new or established patient). The data that were retrieved were the patient's diagnosis of dental caries, patient's age, patient's gender, the patient's caries risk assessment status, the patient's history of e-cigarette/vape use, the patient's history of conventional cigarette use and their axiUm record number. The participants were then assigned identification codes to ensure confidentiality of the patient records in the data set. The caries risk categories were 'low', 'moderate' and 'high' (the high and extreme categories were combined for analysis). These categories were combined to be in alignment with several studies that have assessed the efficacy of CAMBRA as a caries risk prediction tool.[27-29] The included participants were grouped according to age into 3 categories: 16-25 years, 26-40 years and 41 years or older.

Statistical Analysis

A convenience sample was obtained from patients who attended the university dental clinics who met the inclusion

criteria. Descriptive statistics (frequencies and percentages) were calculated. Bivariate analyses were conducted using the Mann-Whitney U test and the Kruskal-Wallis test. Multivariable analysis was also performed using ordinal logistic regression in order to adjust for gender and age category as potential confounding variables. The significance level was set at α=.05. SPSS v. 28 (IBM Corp., Armonk, NY, USA) was used in the analysis.

RESULTS

Of the 1251 patients who attended the university dental clinics from 01.01.2019 to 02.01.2023 who met the inclusion criteria, 130 patients reported active use of e-cigarettes/vapes only and 1094 patients reported active use of conventional cigarettes only. A total of 27 patients reported use of both e-cigarettes/vapes and conventional cigarettes. Of the total participants, 61.1% self reported as male while 38.9% self reported as female. When categorized based on age 3.4% of the participants were in the 16-25 years group, 31.8% in the 26-40 years group and 64.8% were in the 41 years or older group.

The distribution of the participants into the CRA categories was as follows: 3.9% were in the low caries risk group, 13.3% were in the moderate caries risk group and 82.7% were in the high/extreme caries risk group. There was no significant difference in caries risk level between the age or gender categories (p=.248 [Kruskal-Wallis test], p=.257 [Mann-Whitney U test] respectively). The Kruskal-Wallis test showed no statistically significant difference in caries risk level among the 3 groups with 88.9% of the dual smokers (both conventional and e-cigarettes), 83.1% of the e-cigarette/vape only users and 82.5% of the conventional cigarette only smokers being placed in the high/extreme caries risk category (p=.693) (Table 1).

Table 1. Cross-tabulations of age, gender, and e-cigarette/vape and conventional cigarette groups with caries risk level

Variable	Category	CRA Level			p
		Low	Moderate	High or extreme	
Age	16-25 (n=42)	0 (0%)	5 (11.9%)	37 (88.1%)	0.248*
	26-40 (n=398)	10 (2.5%)	52 (13.1%)	336 (84.4%)	
	41+(n=811)	39 (4.8%)	110 (13.6%)	662 (81.6%)	
Gender	Male (n=764)	31 (4.1%)	93 (12.2%)	640 (83.8%)	0.257**
	Female (n=487)	18 (3.7%)	74 (15.2%)	395 (81.1%)	
Study group	E-cigarette/vape and cigarette use (n=27)	1 (3.7%)	2 (7.4%)	24 (88.9%)	0.693*
	E-cigarette/ vape use only (n=130)	3 (2.3%)	19 (14.6%)	108 (83.1%)	
	Cigarette use only (n=1094)	45 (4.1%)	146 (13.3%)	903 (82.5%)	
	Total (n=1251)	49 (3.9%)	167 (13.3%)	1035 (82.7%)	

*Kruskal-Wallis test, **Mann-Whitney U test

Table 2 presents the results of the multivariable ordinal logistic regression. The regression model showed no significant evidence of misfit (p=.275). There was no significant difference in caries risk level among the age groups (p=.252), genders (p=.234), or e-cigarette/vape and conventional cigarette groups (p=.719) when adjusting for one another.

Table 2. Results of the multivariable ordinal logistic regression model including age, gender, and e-cigarette/vape and conventional cigarette groups as factors and caries risk level as the outcome

Variable	Category	OR	95% CI for OR		p*
			Lower limit	Upper limit	
Age	16-25	1.88	0.68	5.15	0.252
	26-40	1.25	0.90	1.75	
	41+**	1	.	.	
Gender	Male	1.20	0.89	1.61	0.234
	Female**	1	.	.	
Study group	E-cigarette/vape and cigarette use	1.54	0.46	5.16	0.719
	E-cigarette/vape use only	0.91	0.54	1.53	
	Cigarette use only**	1	.	.	

*All p-values are from multivariable ordinal logistic regression, **Reference category

DISCUSSION

Though the percentage of patients in the high/extreme caries risk category was highest in the dual smokers group, followed by the vaping/e-cigarette use only group and lastly the conventional cigarette only group, there was no statistically significant difference, even after adjusting for age and gender as potential confounders. Therefore, the null hypothesis was not rejected. A cross-sectional study done on records from the 2017-2018 National Health and Nutrition Examination Survey demonstrated that participants who were dual smokers (smoked e-cigarettes and conventional cigarettes) were more likely to have untreated caries when compared to non dual smokers.[13] These results are similar to those of this current study, with the exception that their results were statistically significant.

Use of tobacco has been shown to increase the prevalence of dental caries by inducing hyposalivation as well as causing a shift in the homeostasis of the oral microbiome.[17-19] E-cigarettes/vape use is hypothesized, through in vitro studies, to have the same effect on the oral environment. In addition to this, e-cigarette/vape use provides a sweet substrate to cariogenic bacteria through their flavoring.[15,16]

In this study, 88.9% of dual smokers, 83.1% of e-cigarette/vape only users and 82.5% of cigarette only smokers were in the high/extreme caries risk category. Though the statistical significance of these differences was not established, there is evidence of a large proportion of the subjects in these groups being in the high/extreme caries risk category. This outcome is concerning, especially when compared to a previous study that compared the caries risk level of vape/e-cigarette using patients and non-smokers. The study found that only 59.6% of non- smokers were classified as high/extreme caries risk. In comparison 79.1% of vape/e-cigarette users were classified as high/extreme caries risk (p<.001).[14]

Tobacco use has been associated with one third of all cancer deaths annually.[30] Sufficient evidence has shown a causal relationship between tobacco use and lung, laryngeal, oral, pharyngeal, esophageal, pancreatic, bladder, kidney and cervical cancers, among others.[31] Evidence on the potential carcinogenicity of e-cigarettes/vapes is still preliminary with molecular science studies showing aberrant morphology, cytotoxicity, reduced viability, oxidative stress, fibroblast

migration and genotoxicity when head, neck and oral cells were exposed to e-cigarette aerosols.[32] E-cigarettes/vape liquids contain both potential and definite oncogens such as nicotine and its derivatives, heavy metals and aldehydes.[33] Given an expected lag time of approximately 20 years, extrapolating from tobacco studies, it may take several years before all the detrimental effects of e-cigarette/vape use fully manifest in the population.[33]

Limitations

The limitations of this study are that it was dependent on the accuracy of patient records which cannot be guaranteed. There was a low percentage of e-cigarette/vape only using patients as well as dual smokers. This could have impacted the findings as smaller sample sizes increase the likelihood of a type II error. Social desirability bias may have played a role in the low number of self reported e-cigarette/vape only users as well as dual smokers. Data on the duration of conventional smoking or e-cigarette/vape use were not collected. The authors hypothesize that since e-cigarettes/vapes are relatively newer to our population, it is more likely that conventional cigarette smokers have been engaging in the habit for a longer time period. There are several confounding variables that could not be accounted for such as socioeconomic status, education level, diet and oral hygiene, which have been associated with drug use in general.[34-37] Lastly, despite having been validated among various populations[38-40], the CAMBRA tool is only 70% predictive of the caries outcome in high risk groups.[38]

Future clinical studies investigating the exact pathophysiology of the increased caries risk among e-cigarette/vape users are recommended. In addition to this, future clinical studies on the potential carcinogenicity of e-cigarette/vape use are highly recommended by the study team.

CONCLUSION

Within the study limitations, it was concluded that though the percentage of patients in the high/extreme caries risk category was highest in the dual smokers group, followed by the vaping/e-cigarette use group and lastly the conventional cigarette group, there was no statistically significant evidence of a difference between these groups. Dental health care providers are encouraged to screen for e-cigarette/vape use in addition to conventional cigarette smoking when gathering information on health history. Further clinical studies are recommended.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of Tufts University Health Sciences Institutional Ethics Review Board (Date: 03.03.2023, Decision No: HS-IRB STUDY00003596).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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